

IN THE SPECIFICATION:

a) Please replace the paragraph beginning at Page 1 in the section entitled "CROSS-REFERENCE TO RELATED APPLICATION" with the following amended paragraph:

--This is a divisional application of copending prior application 10/202,945 filed on July 24, 2002 entitled "Method and Apparatus for Controlling A Piezo Actuator" which application is a divisional of application 09/706,369 filed Nov 3, 2000 entitled "Method and Apparatus for Controlling A Piezo Actuator" subsequently issued as Patent No. US 6,476,537 ~~This~~ which application claims the benefit of priority from Provisional Application Number No. 60/163,329, filed 11/03/99, entitled "PICO Motor Driver" filed on 11/03/99 (Attorney Docket#NFC1P014P) the disclosures of which is are incorporated herein by reference ~~in its entirety~~ for all purposes. --

b) Please replace the paragraph beginning at Page 13, Line 10, with the following amended paragraph:

-- An actuator cut-out 600 in base member 170 accommodates a piezoelectric cover and frame element 610. The piezoelectric element 176 has s a spherical cap 620 on a first end portion and a brass drive pad 616 on a second end portion. Spherical cap and drive pad may be affixed to piezoelectric element by suitable adhesive such as epoxy. Bias spring 614 fits between drive pad and the base is held in position by spring adjustment screw 612. The spherical cap 620 bears against the first opposing face of the base and allows motion of piezoelectric element 176 to accommodate runout of the rotary stage 172. The drive pad 616 has a bias spring retention means slot which accepts the tapered end of bias spring 614. The bias spring adjustment screw 612 has a tapered point and engages in the screw mount hole to engage one end of the bias spring. The bias spring is positioned to force drive portion of the drive pad into engagement with the cylindrical drive surface portion 602 of rotatable stage member and to simultaneously force the spherical cap of the piezoelectric element against frame element face. --

c) Please replace the paragraph beginning at Page 6, Line 22, with the following amended paragraph:

-- The piezo-electric assembly 102 includes an actuator 148 a driven member 158, and a frame 146. The actuator has jaw elements (See FIG. 5) positioned about the driven member, e.g. a cylindrical shaft, which includes a threaded portion 144 passing through the jaws. The base of the piezoelectric actuator is affixed to the frame 146. For the purpose of this explanation, the inertial characteristics of the driven member are represented by the flywheel portion 140 at the head of the ~~cylindrical shaft~~ driven member 158. Where closed loop control of the position of the driven member is enabled position detector 150 operating with linear encoding 142 on the shank of the driven member provides position feedback to the controller 100. --

d) Please replace the paragraph beginning at Page 7, Line 1, with the following amended paragraph:

-- When the electrical signal across piezo-electric element 160 is such that element extends relative longitudinal movements of jaw elements occurs. If there is no slippage between the jaws and ~~shaft~~ driven member 158 rotation of the ~~shaft~~ driven member takes place in the direction of arrow 154. As the amplitude of the electrical signal across piezoelectric element is reduced, contraction occurs, causing relative longitudinal movement of the jaw elements in the opposite direction. Again assuming that no slippage occurs between the jaws and ~~shaft~~ driven member, rotation of ~~shaft~~ driven member takes place in the direction of arrow 156. A spring clip 152 generates clamping force of the opposing jaws on the threaded portion of the ~~shaft~~ driven member. --

e) Please replace the paragraph beginning at Page 7, Line 10, with the following amended paragraph:

-- Because of the inertia of the ~~shaft~~ driven member 158, a rapidly rising or falling electrical signal will induce such rapid movement of the jaw elements that slippage between the jaws and the ~~shaft~~ driven member will occur. The duration of slippage depends on the waveform and amplitude of the electrical signal applied across the piezoelectric element 160, as well as the mechanical characteristics of the system, such as the frictional engagement between the jaws and ~~shaft~~ driven member, and the inertia of the ~~shaft~~ driven member and other mechanical elements connected to it. Conversely, application of a slowly rising or

falling signal across piezoelectric element will cause a correspondingly slow longitudinal movement of the jaw elements, and very little or no slippage between the jaws and shaft driven member will take place. --

f) Please replace the paragraph beginning at Page 7, Line 19, with the following amended paragraph:

-- It follows that selective rotation of ~~shaft~~ driven member 158 may be obtained in either direction 154-156 simply by applying a cyclic electrical signal having the proper waveform to the piezo-electric element 160. Thus, a waveform having a slowly rising leading edge followed by a rapidly falling trailing edge will cause rotation in a first direction. Conversely, a waveform having a rapidly rising leading edge followed by a slowly falling trailing edge will be effective to rotate the ~~shaft~~ driven member in the opposite direction. --

g) Please replace the paragraph beginning at Page 7, Line 28 and carrying over to page 8, with the following amended paragraph:

-- The rotary piezo-electric assembly 104 is a rotary optical stage. It includes a piezoelectric element 176 mounted in a piezo-electric actuator 174 which is affixed to the base member 170 to which a driven member, e.g. rotary stage 172 is rotatably coupled. An optical element such as a diffraction grating, mirror, polarized, or similar device may be affixed to the rotary stage. Cut out portions in base member allow the rotatable stage member to be grasped by hand for manual rotation. A knurled portion on the top of rotary stage may be used in conjunction with scale on the top of rotatable stage member 194 to achieve a coarse initial position. Where closed loop control of the position of the driven member is enabled position detector 178 operating with encoding on the rotary stage provides position feedback to the controller 100.--

h) Please replace the paragraph beginning at Page 12, Line 6, with the following amended paragraph:

-- FIG. 5 is a detailed cross-sectional view of a first of the piezo-electric assemblies actuators 148 shown in FIG. 1. This actuator includes a piezoelectric element 160 having

electrodes 512 and 510 at opposite ends with lead wires electrically connected thereto to allow the analog waveform output by the amplifier 116 (See FIG. 1) to be applied across piezoelectric element. A first end of the piezoelectric element adjacent electrode 510 is affixed to the base portion of the actuator frame (body), and an opposite end is affixed to a first movable jaw element 504, which co-acts with second movable jaw element 502 to engage ~~an adjustment screw~~ a driven member 158 (See FIG. 1) held between the inner faces 528 and ~~506~~ 526 of the jaws. --

i) Please replace the paragraph beginning at Page12, Line 15, with the following amended paragraph:

-- Resilient flexure connects base portion and the first movable jaw element to accommodate bi-directional lengthwise longitudinal motion of piezoelectric element 160. Such lengthwise motion of element 160 causes a longitudinal reciprocating motion of jaw elements, which in turn imparts a rotational motion to a cylindrical element, such as a threaded driven member e.g. adjustment screw, held between inner faces of the jaws. A pair of spring retention grooves 522-524 on the opposing outer surfaces of the jaws serve to position and retain a flat clamp spring 152, as shown in FIG. 1. This clamp increases the pressure of the inner faces of the jaws against the cylindrical element, such as a threaded ~~adjustment screw~~ driven member, positioned between them. The actuator frame may be fabricated from suitable brass stock by means of conventional wire elector-discharge machining techniques. Flat clamp sprint 152 may be fashioned from any material having suitable spring and fatigue characteristics.--

j) Please replace the paragraph beginning at Page13, Line 1, with the following amended paragraph:

-- FIG. 6 is a detailed cross-sectional view of the rotary piezo-electric ~~assembly~~ actuators 174 shown in FIG. 1. The stainless steel rotatable stage member 172 has a complementary stainless steel lower member 604 each of which screwingly secure to each other. The rotatable stage member includes outer surface threads aligned beneath the outer cylindrical drive surface 602. Internal threads are located on the walls of an aperture within the rotatable stage member 172 to accommodate an optic or other device. Upper stage

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member and lower member have beveled bearing races which combine with a complementary race in the base member 170 to provide a high precision, low friction ball bearing for rotation of stage member 172. --